PATENT SPECIFICATION

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(54) WAVE-ACTIVATED GENERATOR

(71) We, KABUSHIKI KAISHA RYOKUSEISHA, a Body corporate existing under the laws of Japan, of 15—14, Tsukiji 2-Chome, Chuo-Ku, Tokyo-To, Japan, do

hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with a water wave-activated electrical generating apparatus in which electricity is generated by utilizing wave energy.

It is an object of the present invention to provide wave-activated generating apparatus of small size and light weight construction.

It is another object of the present invention to provide wave-activated generating apparatus, in which the stability of the apparatus at the time at which air is drawn into the apparatus is improved so as to obtain better results in the starting performance of the generating device whereby electricity can be generated more efficiently.

According to the present invention there is provided a water wave-activated electrical generating apparatus which comprises in combination a tube, both ends of which are open, and which is so adapted that in use a part of it projects above the surface of the water in which the apparatus is situated, the remaining part of which is submerged in the water; an air turbine driven generator mounted in or at the end of the said tube which in use is uppermost, a turbine wheel shaft thereof being aligned parallel to and preferably on the axis of the said tube and the axis of the said wheel shaft when extended lying within the confines of the tube; and at least one air suction valve provided in the peripheral surface of the part of the said tube which is arranged to project above the surface of the water in use, the said suction valve or valves being arranged only to permit air to be sucked therethrough into the said tube; the said tube being arranged to float by means of a float fixed on the outer peripheral surface of the tube below the said air inlet valve of the said tube, desirably above the mid point thereof.

The invention may be put into practice in various ways and one specific embodiment will be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a schematic side elevational view of one embodiment of wave-activated generating apparatus according to the present invention;

Figure 2 is an enlarged side elevational view, partly in longitudinal cross-section, of the upper portion of the wave-activated generating apparatus;

Figure 3 is a cross-sectional view taken along the line III—III of Figure 2; and

Figure 4 is a longitudinal cross-section taken along the line IV—IV of Figure 3.

Referring now to Figures 1 and 2, the wave-activated generating apparatus according to the present invention has a single upright open ended tube 1, a part 3 of which is submerged in the water and the remaining part 2 of which projects upwardly from the surface of the water. Weights 30 are attached to the bottom of the tube 1. A float 4 is fitted around the outer peripheral surface of the tube 1 above the mid point thereof, so that the device may float on the water surface. The mid point of the float is desirably 20% of the distance from the top end of the tube to its bottom end. The upper part 2 is provided at its open top end with an electric generator 5 driven by an air turbine. The turbine is mounted on an inverted cup-shaped holding member 7 with its turbine wheel shaft 6 directed downwardly and in alignment with the axis of the tube 1 as shown in detail in Figure 2. The inverted cup-shaped holding member 7 has air vent ports 8 formed in it around its entire circumference. The turbine wheel 9 of the generator 5 is fixed on the turbine wheel shaft 6 at its downwardly directed end part so that it may be accommodated within the abovementioned inverted cup-shaped holding member 7. A guide plate 11 having therein a plurality of air inlet ports 10 is located at the open top end of the part 2 of

the tube 1 in juxtaposed relationship to the turbine wheel 9. An air current dispersion plate 12 of substantially frusto conical shape is located on the opposite side of the guide plate 11 so as to uniformly distribute the air current from the tube 1 into each of the ports 10 formed in the guide plate 11.

A plurality of inlet suction valve means 13 enabling air to be sucked into the tube 1 from the external atmoshere are provided on the outer periphery of the part 2 of the tube 1 at a portion above the float 4 at substantially equally spaced intervals (in the embodiment as shown in Figure 3 of the drawing, three equispaced valves are provided). The construction of each of the inlet suction valve means 13 is shown in Figure 4. A substantially tangential part of a circular valve body 15 is fitted at the upper, inner end part of an air intake 14 in the form of, for example, a short circular cylinder, by means of a hinge 16 so that the valve may open and close freely. The outer diameter of the valve body 15 and the inner diameter of the circular cylindrical intake 14 are respectively determined in such a way that, when the valve body 15 is in its closed position, it may be stopped within the cylindrical intake with a certain inward inclination toward the tube 1, namely with its lower edge nearer the axis of the tube 1 than is the hinge. This is shown in Figure 2. Also, outside of the valve body 15, there is provided a valve seat 15*a* which is parallel to the valve body 15 when in its closed position. Further, at the outer end part of the cylindrical intake 14, there is fitted a valve protection plate 18 having therein numerous small holes 17 to permit passage of air therethrough. Inwardly of this plate 18, an air-cleaner may be provided if desired. The valve means 13 is mounted in a port 19 formed in the peripheral surface of the tube 1 in such a manner that the valve body 15, when closing, may be stopped at the inner periphery of the circular cylindrical intake 14 with inward inclination toward the centre tubing 1 as described above; the valve means 13 is then secured to the port 19 by welding. The top open end of the part 2 of the tube 1 is covered by an inverted cup-shaped cylindrical cover 20 which protects the generator 5 from the waves. The cover 20 is securely fixed to the tube by butt-connections between a plurality of L-shaped brackets 21 fixed to the inner peripheral edge surface of the cup-shaped cylindrical cover 20 at equally spaced intervals and a plurality of cooperating L-shaped brackets 22 corresponding in number to the above-mentioned L-shaped brackets 21 and fixed on the outer peripheral surface of the tube 1 in the same manner. These butt-connected brackets are firmly secured together by bolts 23.

The operations of the wave-actuated generating apparatus of the above described construction will now be described.

As shown in Figure 1, the apparatus floats on the surface and is moored by means of chains 24 and a block anchor 25. When the entire apparatus moves downward by the movement of waves, the water level within the tube 1 rises to a level A as shown in the drawing, and air within the tube is compressed by the piston action of the water column therein, and owing to the air pressure produced the valve means 13 are held closed. The pressurized air current flows through each of the ports 10 provided in the guide plate 11 by way of the dispersion plate 12 and causes the blades of the turbine wheel 9 to rotate and generate electricity. The air used for rotating the turbine wheel 9 is thereafter exhausted through the exhaust ports 8 provided in the circumference of the holding member 7, to the outside via an annular opening 26 located between the inverted cup-shaped cover 20 and the upper part 2 of the tube 1.

Subsequently, when the entire apparatus is elevated by the movement of the waves, and the water level in the centre tubing 1 drops to a level *B* as shown in the drawing, little or no suction of air occurs in through the opening 26 of the protective cover 20, with the result that a reduced air pressure is produced in the interior of the tube 1. The valves 13 thus open inwardly as indicated by the double dots and dash lines as shown in the drawing, and air flows into the tube 1 from the exterior through the cylindrical intakes 14.

Thereafter, as the above-described movements are repeated, the turbine wheel 9 is rotated by the air current introduced into the tube 1 and compressed by the piston action of the water column within the tube, as the apparatus moves downwardly, and the wave energy is constantly, repeatedly and regularly converted into electrical energy only during this downward movement of the apparatus. During the upward movement of the device air flows substantially only through the intakes 14 into the tube 1 below the turbine 9 and thus during this part of the sequence little or no movement of the turbine occurs. The thus produced electrical energy is accumulated first in one or more storage batteries and then consumed to illuminate a warning light and/or to sound a fog warning horn.

Since the wave-activated generating apparatus according to the present invention is so constructed as to enable the turbine wheel shaft 6 of the electric generator 5 to be disposed in alignment with the axis of the tube 1, it is possible to make the size of the generator substantially the same as or smaller than the diameter of the

tube 1, and as a result the apparatus as a whole can be constructed in a simple, miniaturized, and light weight form. While the valve means 13 may be single and of a large diameter, it will be more convenient, if a plurality of small-sized inlet suction valves are arranged at substantially equally spaced intervals on the periphery of the tube as shown in the drawing by way of an embodiment, since this enables the valve body 15 *per se* to be made in a light weight form, hence the opening and closing operations thereof become smooth and are less liable to give mechanical trouble. Moreover, since the generator is covered by the protective cover 20, it is protected from damage by salt contained in the water.

In addition when the valve body 15 of the valve means 13 is set in the shallow cylindrical intake 14 and is inclined inwardly toward the inside of the tube 1, the air sucking action becomes smooth, and the risk of failure of the closing action thereof every time air is to be compressed within the tube 1 is much reduced.

WHAT WE CLAIM IS:—

1. A water wave-activated electrical generating apparatus which comprises in combination:

a) a tube, both ends of which are open, and which is so adapted that in use a part of it is arraged to project upwardly above the surface of the water in which the apparatus is situated, and the remaining part of which is submerged in the water;

b) an air turbine-driven generator mounted in or at the end of the said tube, which in use is uppermost, a turbine wheel shaft thereof being aligned parallel to the axis of the said tube and the axis of the said wheel shaft when extended lying within the confines of the tube;

c) at least one air inlet suction valve provided in the peripheral surface of the part of the said tube which is arranged to project above the surface of the water in use the said suction valve or valves being arranged only to permit air to be sucked therethrough into the said tube; and

d) the said tube being arranged to float by means of a float fixed on the outer peripheral surface of the tube below the said air inlet valve of the said tube.

2. A wave-activated generating apparatus as claimed in Claim 1 in which the end of the tube which in use is uppermost and the generator mounted at that end are covered by a cylindrical cup-shaped cover.

3. A wave-activated generating apparatus as claimed in Claim 1 or Claim 2 in which a plurality of air inlet suction valves are provided in the peripheral surface of the said tube at substantially equally spaced intervals.

4. A wave-activated generating apparatus as claimed in Claim 1, 2 or 3 in which the or each air inlet valve is mounted at an angle to the longitudinal axis of the said tube in a cylindrical intake so as to open easily when air is taken into the tube through the said cylindrical intake.

5. A wave-activated generating apparatus as claimed in Claim 1 substantially as specifically described herein with reference to the accompanying drawings.

KILBURN & STRODE,
Chartered Patent Agents,
Agents for the Applicants.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1

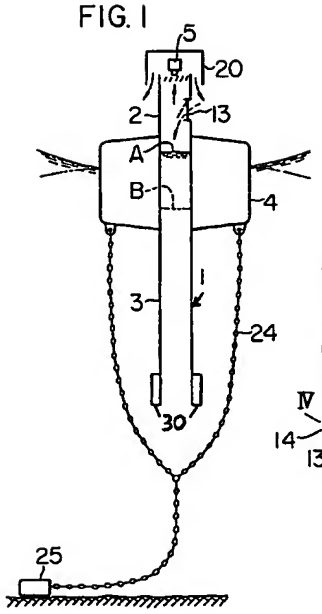


FIG. 3

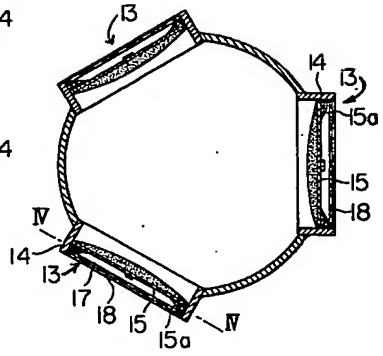
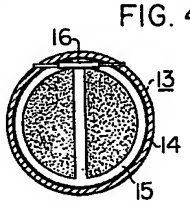


FIG. 4



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Sheet 2

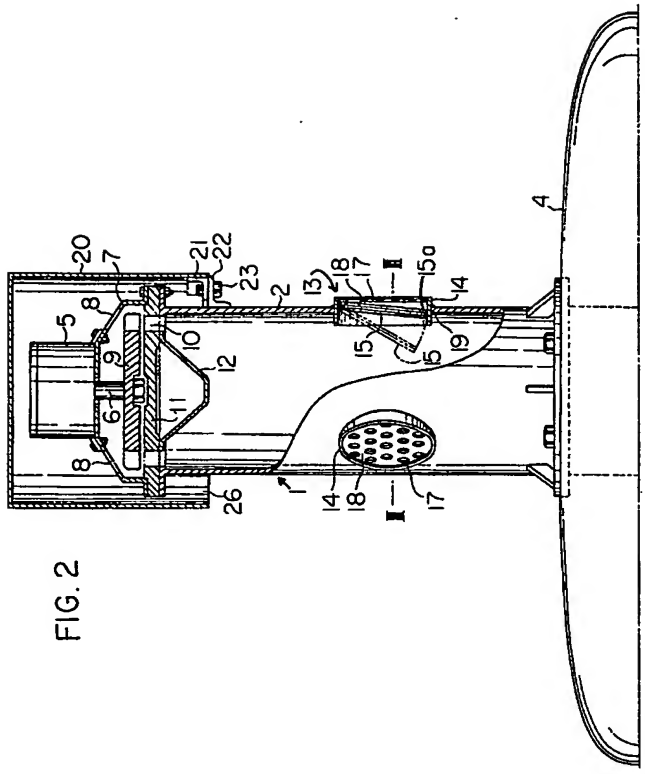

FIG. 2